Life-Cycle Environmental Impacts of Sensor-based Variable N-Rate Fertilization

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INTRODUCTION

Corn's need for N fertilizer vary widely over large fields. Scharf et al. conducted experiments to compare sensor-based variable N rate fertilization for corn to producer rate fertilization, observing that N use was reduced by variable rate fertilization. It has been suggested that variable rate nitrogen fertilization has potential for environmental benefits through higher yield efficiency, higher nitrogen fertilizer recovery efficiency, lower unaccounted for N, and less postharvest inorganic N. But no studies have quantified the environmental benefits of sensor-based variable rate fertilization. The potential in-field environmental benefits may be partially off-set or expanded by emissions elsewhere in the life cycle, such as fuel use, and upstream emissions. The objective of this research is to apply Life Cycle Assessment (LCA) to compare the environmental impacts of corn grown using sensor-based variable N rate fertilization and corn produced using a producer selected N rate.

MATERIALS & METHODS

- Experiment Site and Treatment Description

The experiment was conducted by Scharf on the Ellis Farm in Lincoln County, Missouri in 2008. The cropping system is corn and soybean with no-tillage. Fertilization was a pre-plant fertilization at 40 lb N/ac, and a side-dress fertilization. The producer selected rate side-dress application is at 77 lb N/ac (yellow strips), and sensor-based variable rate side-dress application ranged from 50 to 85 lb N/ac (red blue strips).

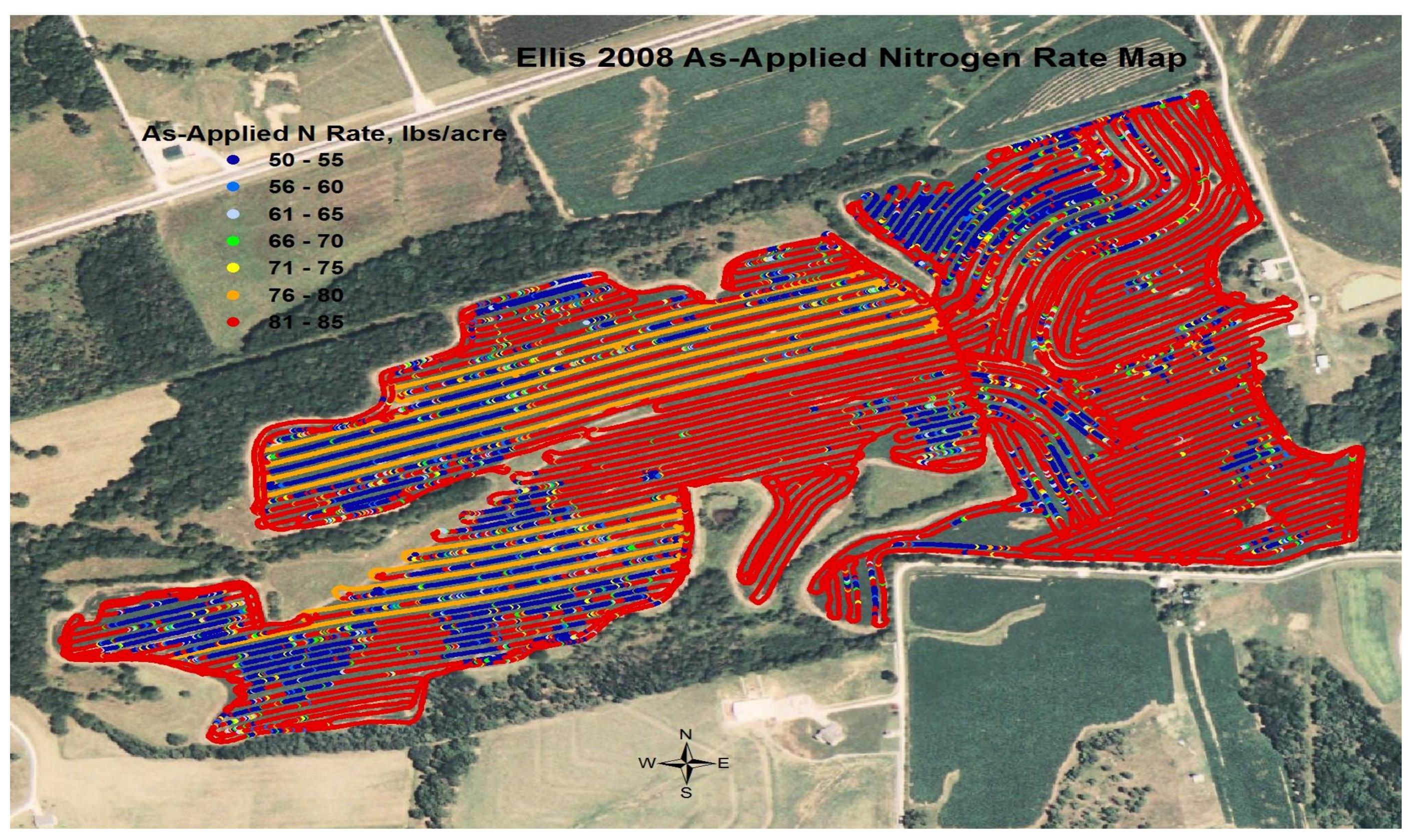


Figure 1. Ellis farm field map showing N-application rates.

- Data Collection

The soil data, including bulk density, pH, clay fraction, organic carbon content, and slope, were taken from soil property maps (10 m resolution), generated by Goodman and Owens using a geomorphic fuzzy logic mapping approach. Analysis was performed at 60 points (30 points from each management system).

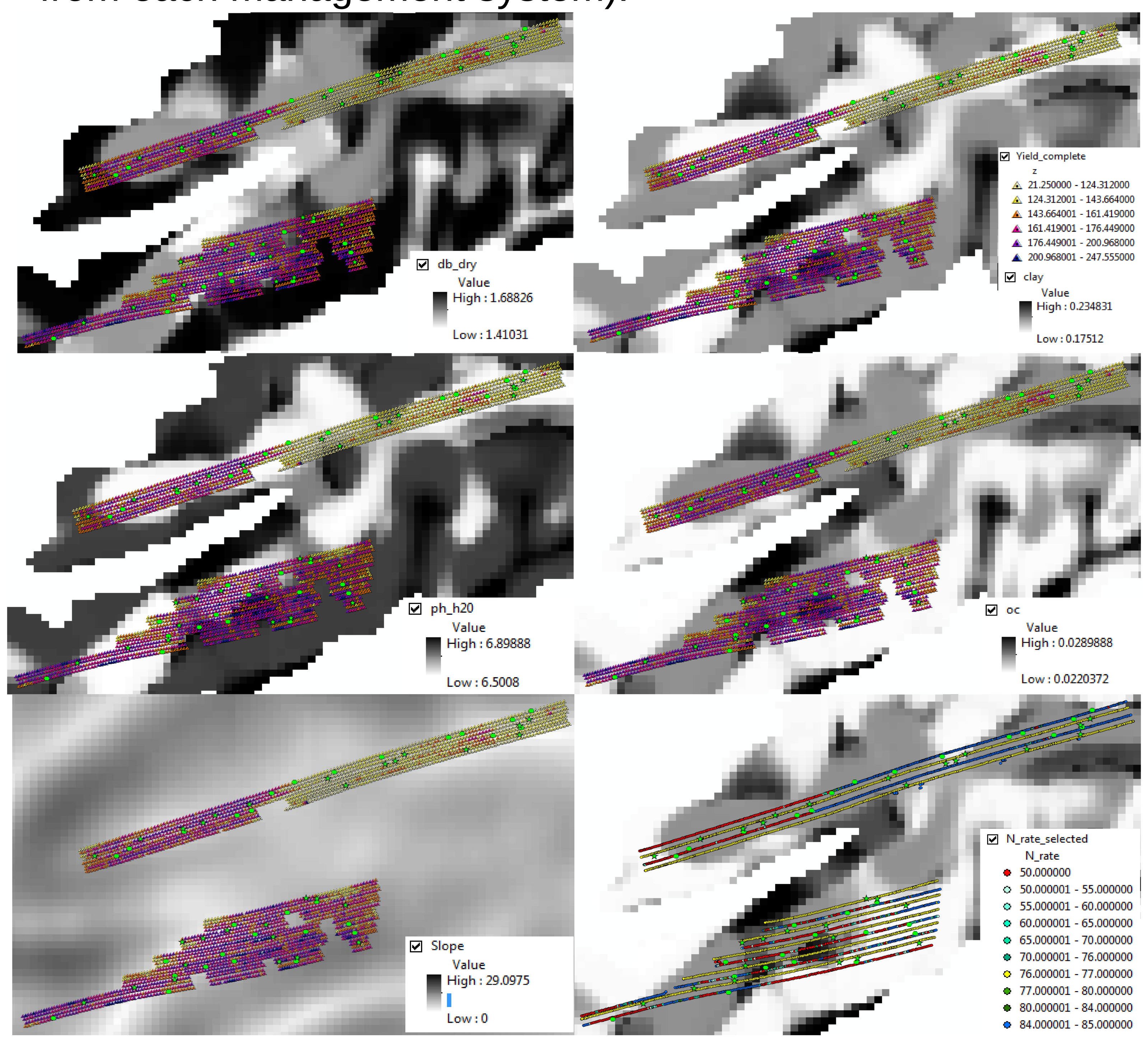


Figure 2. Soil property maps with N rate and yield data.

- Soil N loss Modeling

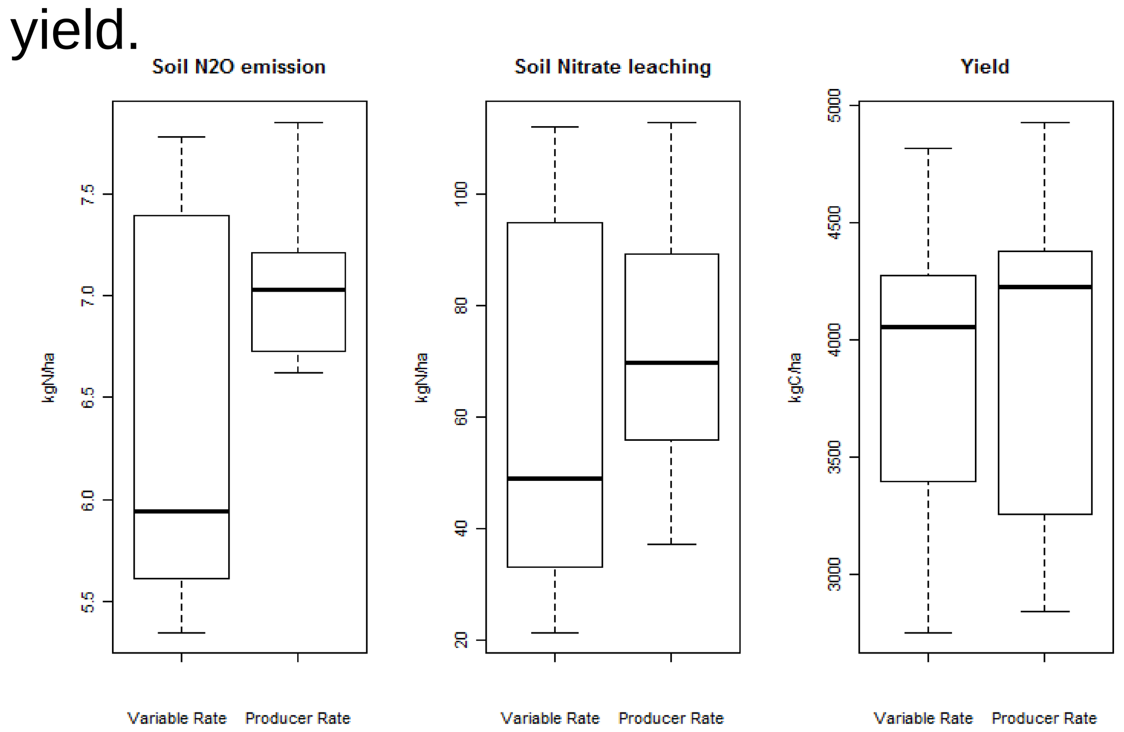
The Denitrification-Decomposition (DNDC) model was used to predict soil N_2O emissions and NO_3^- leaching for the Life Cycle Assessment. Yield data are used for calibrating the DNDC crop model.

- Life Cycle Assessment

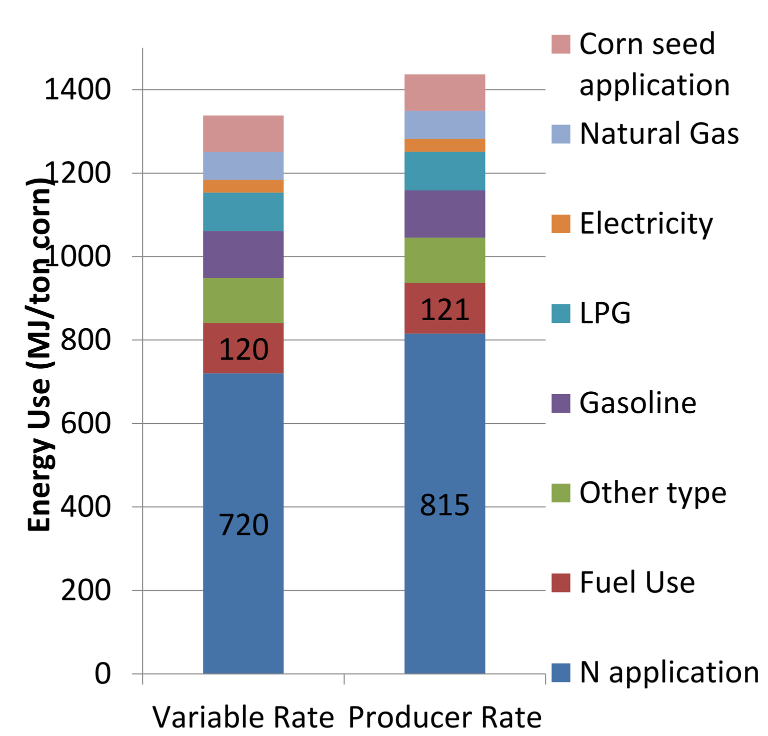
The scope is from planting to harvesting. Functional unit is one ton of corn grain. Life Cycle Impact categories include energy consumption, GHG emissions, and NO_3^- leaching.

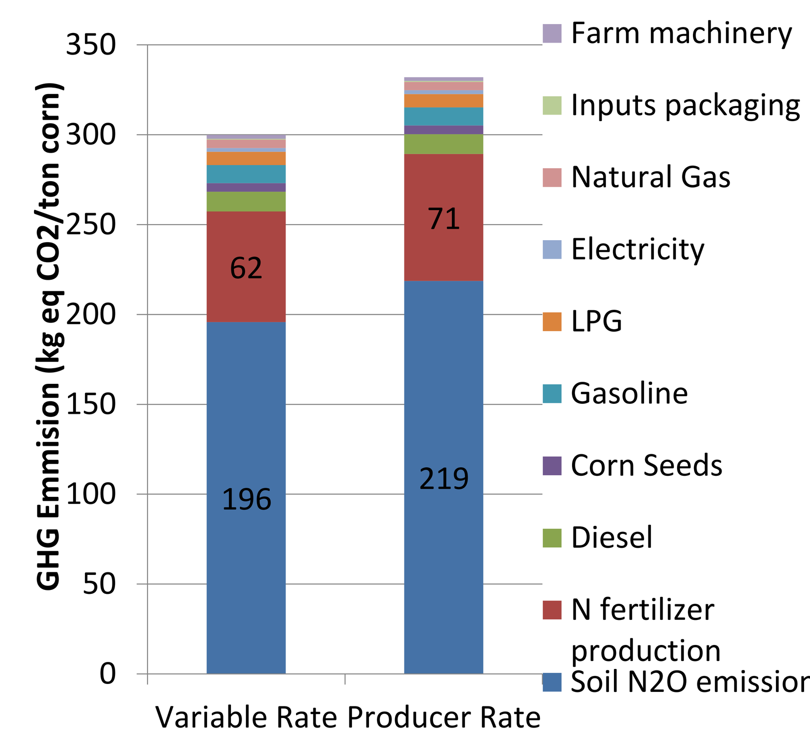
RESULTS & DISCUSSION

- Modeled soil N_2O emission and NO_3^- leaching and actual corn yield.



- Life-cycle energy consumption and GHG emissions





CONCLUSIONS

- Variable N-rate fertilization reduced N fertilizer usage 11%, while increasing yield by 0.4%.
- Based on DNDC modeling, variable N-rate fertilization reduced soil N_2O emissions by 10% and NO_3^- leaching by 15% on average in 2008 at this location.
- On a life-cycle basis, energy consumption per kg of corn was reduced by 6%; GHG emissions per kg of corn were decreased by 9%.
- Experiments without such restrictive N-rate limits are expected to show even greater reductions in N-loss under variable N-rate fertilization.

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